Feb. 20, 1945. C. E. HALLMARK 2,369,824

KEYSTONE CORRECTION CIRCUIT

Filed April 30, 1942

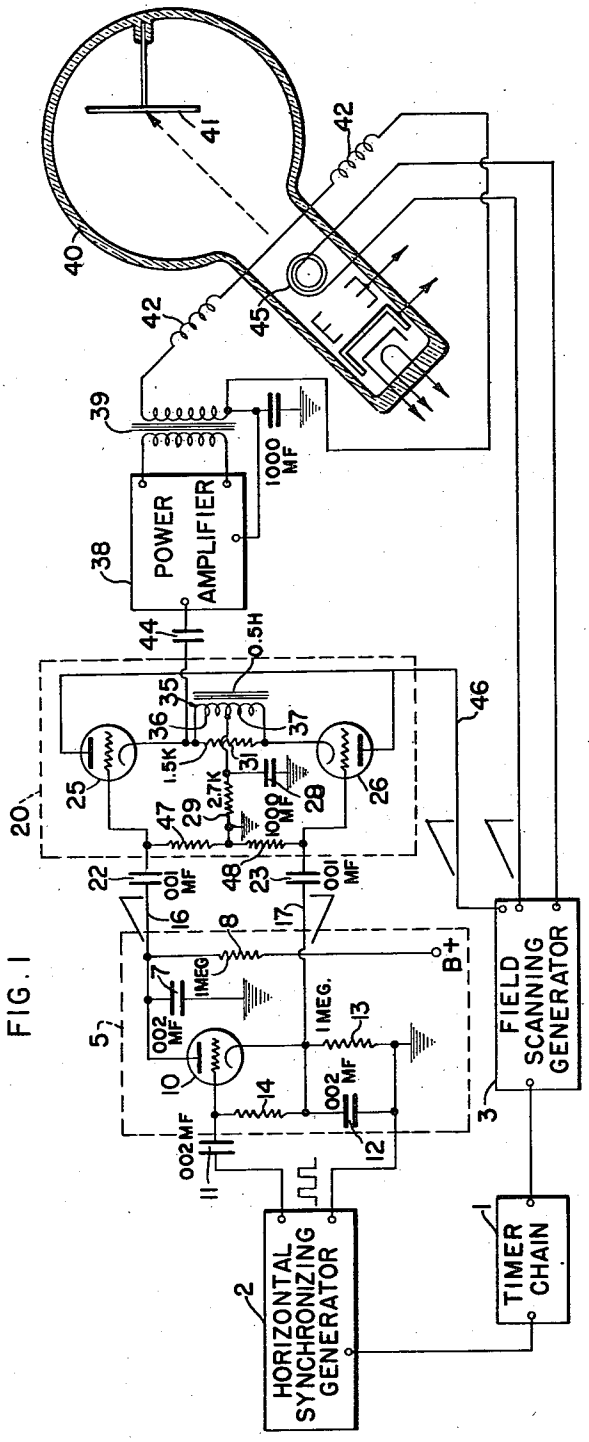


FIG. 1

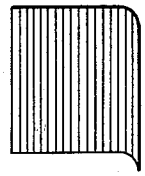


FIG. 4

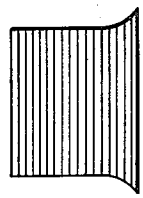


FIG. 3

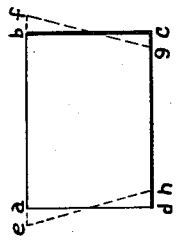


FIG. 2

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KEYSTONE CORRECTION CIRCUIT

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4 Claims. (Cl. 175—335)

This invention relates generally to a scanning system for television systems and more particularly to scanning circuits for correcting keystone distortion in such systems. This invention is a modification of that disclosed in applicant's copending application Serial No. 437,118 dated April 1, 1942, for Keystone correction circuit.

As is well known in the art, certain types of cathode ray tubes now in general use for converting optical images into electric signals entail the production of pictures having a keystone pattern instead of the desired rectangular pattern. This so-called keystone effect results from the fact that the mosaic of the tube, in order to be supported perpendicularly to the optical system which focuses the picture to be transmitted, must be disposed at an angle to the axis of the electron gun. Thus, even though the beam is deflected horizontally through the same angle for each line of the scanning pattern on the mosaic, it actually traces shorter lines toward the bottom of the mosaic than at the top since the lower part of the mosaic is at a lesser distance from the electron gun.

Keystone distortion may be corrected so that a scanning pattern is produced which is of substantially rectangular configuration by modulating the horizontal scanning wave in accordance with the instantaneous amplitude of the field scanning wave. Thus, as a field is traced, the field scanning wave modulates the horizontal scanning wave to gradually alter the length of successive horizontal scanning traces so that the keystone effect is compensated for and a substantially rectangular field is scanned.

While certain scanning systems of the prior art have accomplished keystone correction to a certain degree, they have failed to produce a rectangular scanning pattern wherein all scanning lines are of precisely the same length and/or entirely free from lengthwise displacement. As a result, in such systems the picture fields reproduced at the television receiver have had ragged vertical sides or the lower portions thereof have included lines of excessive length and/or lines which were displaced lengthwise. The scanning fields of these systems have been particularly distorted at their lower edges. These forms of residual distortion have been found to be the result of modulation distortion and of the failure of the systems to remove the higher order frequency components of the field scanning frequency from the modulated horizontal scanning wave. It is possible to eliminate the fundamental of the field scanning frequency from horizontal scanning voltages, but prior to the present invention no apparatus has been provided for eliminating the higher order of frequency components of the field scanning frequency as well as the fundamental thereof.

Accordingly, the primary object of this invention is to provide a novel method and apparatus for obtaining keystone correction in television systems and for eliminating the distortion in such systems which is effected by keystone correction.

Another object of this invention is to provide a novel modulation circuit in connection with the horizontal scanning circuit of a television system for correcting keystone distortion, such modulation circuit to require only a low voltage power supply.

A further object of this invention is to provide a keystone correction circuit particularly adapted for use in connection with electromagnetic scanning systems in cathode ray apparatus.

A still further object of this invention is to provide a method and apparatus for eliminating higher order distortions of the scanning fields in television systems by reducing the potentials to ground in the output circuit of the horizontal scanning control circuit.

There is provided in accordance with this invention, a horizontal scanning control circuit comprising a scanning generator for generating simultaneous line scanning waves of equal amplitude but of opposite phase. These waves are simultaneously impressed on the input of a balanced modulator wherein their amplitude is modulated in accordance with the instantaneous amplitude of each field scanning wave. There is provided in the cathode circuit of the balanced modulator, a choke coil wherein field scanning fundamental frequencies together with the higher order components thereof are balanced to eliminate them. The modulated line scanning waves are added in the balancing choke coil and impressed on the line scanning deflection coils of the cathode ray tube. The balancing choke coil is connected at its mid point to ground through a reactance which has an extremely low value at the frequency involved and therefore, substantially no potential appears in the output circuit having frequencies corresponding to the fundamental field scanning frequency or its higher order components. The particular circuit and method of balancing the various components of the field scanning wave to obtain the modulated horizontal scanning wave, provides a picture field having substantially perpendicular sides and also sides of straight line form so that there is no

sensible distortion of the rectangular scanning field.

For a better understanding of the present invention, together with other and further objects thereof, reference is had to the following description taken in connection with the accompanying drawing and its scope will be pointed out in the appended claims.

Referring to the drawing:

Fig. 1 is a circuit diagram illustrating the preferred embodiment of the invention;

Fig. 2 is a diagram illustrating keystone distortion together with the desired rectangular scanning field;

Fig. 3 is a diagram illustrating one type of distortion occurring in conventional keystone corrected scanning fields; and

Fig. 4 is a diagram illustrating distortion occurring in conventional keystone corrected scanning fields as a result of the presence in the horizontal scanning wave of higher order components of the field scanning wave.

In Fig. 1 of the drawing, there is illustrated a circuit for generating line scanning waves and a modulating circuit for introducing keystone correction, together with a cathode ray tube for transmitting electrical signals corresponding to an optical image. There is provided a conventional timer chain 1 for generating synchronizing pulses to control the horizontal synchronizing signal generator 2 and the field scanning signal generator 3. The output signal of horizontal synchronizing signal generator 2 comprises a series of square-top pulses having a frequency depending upon the number of lines it is desired to scan. It may be assumed for purposes of illustration that the image will be scanned at the rate of 30 frames per second. The horizontal scanning will be of the order of 525 lines per frame and, therefore, the horizontal scanning frequency will be of the order of 15,750 cycles per second.

The horizontal synchronizing pulse wave is converted into a saw-tooth scanning wave by the saw-tooth wave generating circuit 5. This circuit includes a first time-constant circuit comprising a condenser 7 and a resistor 8 which are connected in the anode circuit of the tube 10. A second time-constant circuit comprising condenser 12 and resistor 13 is connected in the cathode circuit of tube 10 and in series with the first time-constant circuit. The two time-constant circuits are identical, as shown by the circuit constants indicated in Fig. 1. Tube 10 is connected with the horizontal synchronizing generator 2 by means of condenser 11 and grid resistor 14. The grid of tube 10 is normally biased to render it nonconductive.

The output of generator 5 is impressed on the conductors 16 and 17 which are connected to the input circuit of a modulator 20 through coupling condensers 22 and 23. Modulator 20 includes a pair of similar thermionic tubes 25 and 26, the cathodes of which are connected to a balanced choke coil 35, and the anodes of which are connected to the output of field scanning generator 3 through conductor 46. Choke coil 35 comprises a pair of matched windings 36 and 37 together with a tap between the two windings which is connected to ground through condenser 28 and resistor 29 in parallel. The choke coil 35 is shunted by resistor 31. A power amplifier 38 is coupled through a condenser 44 to the output circuit of the balanced modulator 20 for converting the horizontal scanning wave into a current wave of the desired amplitude.

A conventional cathode ray tube 40 may be connected with a suitable source of potential, not shown, for generating a cathode ray beam for scanning mosaic 41. It is to be noted that mosaic 41 is supported at an angle to the axis of the electron gun of the tube in the well-known manner so that the optical image may be focused directly on the mosaic. Thus, as mentioned hereinbefore, the cathode ray beam normally would scan a field having a keystone configuration as distinguished from the desired rectangular shape. In accordance with the present invention, however, the output of amplifier 38 is coupled with deflecting coils 42 of the tube 40 through transformer 39. Transformer 39 should have such characteristics that it will not introduce appreciable distortion in the horizontal scanning wave having a fundamental frequency of the order of 15,750 cycles. The timer chain 1 supplies timing impulses to the field scanning generator 3 wherein saw-tooth voltages are generated in synchronism with the timer chain output for controlling the field scanning of mosaic 41. This control is accomplished by field scanning coils 45. The field scanning voltage waves are also impressed on the anodes of modulator tubes 25 and 26 through conductor 46 connected as shown in Fig. 1. The anode polarizing potential for tubes 25 and 26 is also fed from any suitable anode circuit of field scanning generator 3 through conductor 46.

In order to transmit electrical signals representative of an optical image, an optical system, not shown in the drawing, focuses the image on mosaic 41 whereupon a cathode ray beam generated by the electron gun of tube 40 is caused to trace successive fields of scanning lines by the windings 42 and 45.

The line scanning is controlled initially from timer chain 1, the output of which consists of a series of timing pulses. Horizontal synchronizing generator 2, controlled by the timer chain 1, develops a series of square-top pulses, as illustrated in Fig. 1, the frequency of these pulses being of the order of 15,750 cycles per second.

Assuming the generator 5 to have reached its stable operation and to be in such condition that its output voltage wave is at its zero point, at this time the tube 10 is biased to cut-off and conditions are such that condenser 7 is gradually charging from anode supply B+ through resistor 8 and the voltage across this condenser therefore is gradually increasing in amplitude. At the same time condenser 12 is discharging at a gradual rate through resistor 13. The rate of charge and discharge of these condensers depends, of course, upon the time-constants of their respective circuits. Since time-constant circuits 7, 8 and 12, 13 are identical, the voltages across condensers 7 and 12 will be respectively increasing and decreasing at precisely the same rate. This change of voltage continues until the timing pulse from the horizontal synchronizing generator occurs, whereupon the bias on the grid of tube 10 is changed to render the tube conductive. Condenser 7 is substantially instantaneously discharged through tube 10 and condenser 12 is simultaneously charged. Hence, there appears across the condensers 7 and 12 simultaneous saw-tooth waves of equal amplitude and opposite polarity. These saw-tooth waves are of a fundamental frequency controlled by synchronizing generator 2, and therefore, are of the order of 15,750 cycles per second.

The saw-tooth voltages are applied across re-

sistors 47 and 48 of modulator 20 and are therefore, impressed on the grids of tubes 25 and 26 and since they are of opposite polarity and of similar shape and amplitude, the inputs of tubes 25 and 26 are balanced. The output of the field scanning generator 3 is impressed on the anodes of tubes 25 and 26 in parallel by way of conductor 46, and therefore, the horizontal scanning waves are modulated to have gradually increasing amplitudes in accordance with the increasing amplitudes of the field scanning waves during each field scanning period. The output currents of tubes 25 and 26 consist of the line scanning waves in opposite polarity together with field scanning wave components in phase with one another. Hence, in the opposing windings 36 and 37 of the choke 35, the line scanning waves are added while the field scanning wave components thereof oppose each other and are cancelled out. Not only is the fundamental of the field scanning wave cancelled out but also the higher order frequency components thereof, the coke 35 having exactly the same number of closely coupled turns in each of its windings 36 and 37. The use of the balancing choke coil 35 provides a single ended output for modulator 20, and therefore, the modulated line scanning wave may be coupled through condenser 44 to power amplifier 38. Power amplifier 38 converts the output of modulator 20 into a saw-tooth current wave of the desired amplitude. The output of amplifier 38 is translated by the transformer 39 and impressed across deflecting windings 42, under the influence of which the cathode ray beam of tube 40 is deflected across the mosaic 41. Picture signals are derived from mosaic 41 in the manner well known in the art.

As pointed out hereinbefore, resistor 29 and condenser 28 are of such values that the impedance to ground from the center tap of choke coil 35 is extremely low at the frequency of 15,750 cycles. Therefore, the potential across choke coil 35 is substantially entirely representative of the modulated horizontal scanning wave. Thus, there may not exist any appreciable higher order components of the field scanning frequency in the output of the modulator. A further advantage arises from this arrangement in that a low voltage power supply is adequate. Since the horizontal scanning waves, modulated during each field, are of increasing amplitude as the beam scans successive lines from the top to the bottom of the mosaic, the scanning field is rectangular, as shown in Fig. 2 at *a*, *b*, *c* and *d*. If the scanning waves are not modulated to correct their amplitude, the field scanned by the beam in tube 40 would have a keystone shape such as indicated by *e*, *f*, *g* and *h* in Fig. 2. Furthermore, the precisely balanced saw-tooth wave generator and modulator circuit, shown in Fig. 1, provides a straight edge scanning field and prevents the scanning field from having an irregular form, such as shown in Figs. 3 and 4 wherein certain lines, as scanned in the mosaic 41, are lengthened or displaced horizontally as a result of modulator unbalance.

The balanced choke coil 35, as provided in accordance with the present invention, is particularly adapted to eliminate the higher order frequency components of the field scanning frequency which appear in the modulated line scanning wave. As described hereinbefore, the coil 35 is wound in such a manner that the turns of each of the windings 36 and 37 lie side by side and adjacent to one another throughout their length. Thus, there is extremely close inductive coupling between windings 36 and 37 and minimum leakage reactance therebetween. If there were a substantial leakage reactance, it would appear as an impedance in series with winding 36 and this would result in a voltage drop across it which would be impressed on coupling condenser 44. Therefore, the higher order frequency components of the field scanning wave in the modulated line scanning waves would create a distortion voltage, corresponding to the higher order components, across the input circuit of power amplifier 38, and distortions would occur in the field scanned by the cathode ray of tube 40. However, the provision of the closely coupled choke coil 35 substantially eliminates the leakage reactance effect and also provides a substantially perfectly balanced output circuit across modulator 20. Thus, there can exist no appreciable distortion in the output of the modulator.

If a coupling element such as a center-tapped transformer were connected across the anode modulator 20, the higher order frequency components in the line scanning waves would not be eliminated from the modulator output. This results from the fact that the construction of transformers and the spacial relation of the coils therein is such that the windings cannot be as closely coupled as those of a choke coil, such as is provided in this invention. Therefore, the transformer would introduce a substantial leakage reactance in circuit with the output circuit of modulator 20 and consequently there would be an appreciable higher order frequency voltage in that circuit which would introduce distortion in the input circuit of amplifier 38 and in the field traced by the cathode ray. From this it is obvious that choke coil 35 provides a very definite advantage over a center-tapped transformer or any other form of coupling wherein leakage reactance occurs.

The various circuit elements of the generator and modulator shown in Fig. 1 have been indicated as having certain constants for purposes of illustrating a workable form of the invention, but it is not intended that the invention should be limited to these specific constants, as it will be obvious to those skilled in the art that the invention is applicable to circuits having entirely different constants for providing various numbers of scanning lines and frames per second. It will also be obvious to those skilled in the art that the invention may be applied to various types of cathode ray tubes wherein keystone correction is necessary.

While there has been described what is at present considered the preferred embodiment of the invention, it will be obvious to those skilled in the art that various changes and modifications may be made therein without departing from the invention, and it is, therefore, aimed in the appended claims to cover all such changes and modifications as fall within the true spirit and scope of the invention.

I claim:

1. In a television system, a keystone correction circuit comprising a pair of vacuum discharge devices connected in push-pull relation and including input circuits, anodes and cathodes, a source of high-frequency pulses coupled to the input circuits of said devices adapted to produce simultaneous saw-tooth voltages of equal amplitudes and opposite polarities, a source of low-frequency saw-tooth voltage connected in parallel with the anodes of said devices for mod-

ulating the amplitude of the high-frequency voltages in accordance with the variation in amplitude of said low-frequency saw-tooth voltage, a balanced choke coil comprising a pair of opposed windings each of which is connected to one of the cathodes of said devices whereby low-frequency components of said modulated voltages are balanced out, and a pair of deflection windings coupled across said choke coil.

2. In combination, a pair of vacuum discharge devices connected in push-pull relation and including input circuits, anodes, cathodes and grids, a source of high-frequency pulses in the input circuits of said devices adapted to produce simultaneous saw-tooth voltages of equal amplitudes and opposite polarities on the grids of said devices, a source of low-frequency saw-tooth voltage connected to the anodes of said devices for modulating the high-frequency voltages, and a balanced choke coil connected between the cathodes of said devices to balance out the low-frequency components of said modulated voltage.

3. In combination, a pair of vacuum discharge devices and including input circuits, anodes and cathodes, a source of high-frequency pulses coupled to the input circuits of said devices, a source of low-frequency pulses connected to the anodes of said devices for modulating the high-frequency pulses, a balanced choke coil connected between the cathodes of said devices to balance out the low-frequency components of said modulated voltage, and a load circuit coupled to said choke coil.

4. In combination, a pair of vacuum discharge devices connected in push-pull relation and including input circuits, anodes and cathodes, a source of high-frequency pulses coupled to the input circuits of said devices, a source of low-frequency saw-tooth voltages connected to the anodes of said devices for modulating the high-frequency pulses, means connected between the cathodes of said devices to balance out the low-frequency components and their higher order components in said modulated voltages and a cathode ray deflection means coupled to said means.

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